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Research article

Aquaculture wastewater treatment through microalgal. Biomass potential applications on animal feed, agriculture, and energy

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ABSTRACT

The use of microalgae to remediate raw effluent from brown crab aquaculture was evaluated by performing batch mode growth tests using separately the microalgae *Chlorella vulgaris* (Cv), *Scenedesmus obliquus* (Sc), *Isochrysis galbana* (Ig), *Nannocloropsis salina* (Ns), and *Spirulina major* (Sp). Removal efficiencies in batch growth were 100% for total nitrogen and total phosphorus for all microalgae. Chemical oxygen demand (COD) remediations were all above 72%. Biomass productivity varied from 20.9 mg L^{-1} day^{-1} (*N. salina*) to 146.4 mg L^{-1} day^{-1} (*C. vulgaris*). The two best performing algae were *C. vulgaris* and *S. obliquus* and they were tested in semi-continuous growth, reaching productivities of 879.8 mg L^{-1} day^{-1} and 811.7 mg L^{-1} day^{-1}, respectively. The bioremediation of the effluent was tested with a transfer system consisting of three independent containers and compared with the use of a single container. The single container had the same capacity and received weekly the same volume of effluent as the three containers together. The remediation capacity of the 3 containers was much higher than the single one. The supplementation with $NaNO_3$ was tested to improve the nutrient removal microalgae' capacity, with positive results. The removal efficiencies were 100% for total nitrogen and total phosphorus and higher than 96% for COD. The obtained *C. vulgaris* and *S. obliquus* biomass were composed of 31 and 35% proteins, 6 and 8% lipids, 39 and 30% carbohydrates, respectively. The composition of these biomass suggest that it can be used as novel and sustainable ingredients in aquaculture feeds. The algal biomass of Cv and Sc were used as biostimulants in the germination of wheat and watercress, and very promising results were attained, with increases in the germination index for Cv and Sc of 175% and 48% in watercress and 84% and 98% in wheat, respectively. The biomasses of Cv and Sc were also subjected to a torrefaction process with 72.5 ± 1.7% char yields. The obtained biochars were tested as biostimulants for germination seeds (wheat and watercress) and as bio-adsorbent of dye solutions.

1. Introduction

Intensive or semi-intensive aquaculture increases the concentration of nutrients in the aqueous medium. This accumulation is due to feed residues and excrements of the aquatic species produced, which stimulates the growth of several microorganisms, some of them pathogenic. In aquaculture, to prevent the development of diseases in animals, antibiotics and other antimicrobial agents are added. These agents of control and prevention of the proliferation of microorganisms may not be completely metabolized or excreted, thus bioaccumulating in the species produced and being transposed to the food chain could constitute a consumers' health risk (Rosa et al., 2020).

The regular discharge of nutrient-rich effluents into adjacent water bodies can also lead to eutrophication phenomena due to the uncontrolled proliferation of algae (micro and macro). This problem is particularly critical when these effluents with high organic and inorganic loads are discharged into aquatic environments with low dispersion rates, such as lakes or estuaries (Fonseca et al., 2021).

Thus the search for alternative and sustainable methods to control the excessive accumulation of nutrients and microorganisms in these growth mediums of aquatic species or in the corresponding effluents has been an area of growing interest (Lin et al., 2020; Paul et al., 2021).

Microalgae are eukaryotic microorganisms with a huge potential to remediate agroindustrial effluents due to their high photosynthetic

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